SPICE: A Geometry Information System Supporting Planetary Mapping, Remote Sensing and Data Mining

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Abstract

SPICE[1] [1] is an information system providing space scientists ready access to a wide assortment of space geometry useful in planning science observations and analyzing the instrument data returned therefrom. The system includes software used to compute many derived parameters such as altitude, LAT/LON and lighting angles, and software able to find when user-specified geometric conditions are obtained. While not a formal standard, it has achieved widespread use in the worldwide planetary science community.

1. Introduction

A necessary if not much loved component of conducting planetary science investigations is the computation of the observation geometry needed to plan science observations obtained from robotic spacecraft, to appropriately archive those data for subsequent use by interested researchers, to retrieve those and related data from worldwide planetary science archives, and to analyze those data, including the making of derived products such as maps. The SPICE system was originally conceived in the Galileo era for supporting science data analysis, but in the years since its use has expanded to support the full life-cycle of space science mission geometry requirements. The core SPICE system is developed at NASA's Jet Propulsion Laboratory, but production and archival of mission SPICE data occurs at most space agencies involved in planetary exploration. With no usage restrictions or cost to individuals, hundreds of scientists around the globe use SPICE data and software in conducting their own research.

2. Using SPICE

The SPICE system's principal components are data files and allied software. The data files–often called kernels–contain fundamental space geometry information such as spacecraft trajectory and orientation, planetary bodies ephemerides, orientations and size/shape, science instrument mounting alignment and field-of-view specifications, data about a host of reference frames (sometimes coordinate systems or coordinate frames), and data used in time system computations (conversions).

To facilitate use of these data the system includes a SPICE Toolkit. This software package is comprised of subroutine modules used to read the SPICE kernels and to then compute high-level derived quantities such as latitude, longitude and lighting angles at an instrument boresight's surface intercept location. A scientist incorporates into his/her own application a few modules selected from the Toolkit–those needed to carry out the geometry calculations pertinent to the task at hand. Such an application might be used in determining where and when to point an instrument in order to acquire meaningful science data, or it might be used to help analyze the data returned from such observations.

SPICE geometry computations are also regularly used in producing meta-data associated with science data archives. Such meta-data may be used by researchers to help retrieve science data from an archive that meet user-specified observing conditions. And they are sometimes used to aid in analysis of these data when the researcher has only modest requirements on the observation geometry parameters needed, and their accuracy.

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[1] **S**pacecraft, **P**lanet, **I**nstrument, **C**amera-matrix, **E**vents: http://naif.jpl.nasa.gov/naif/spiceconcept.html

Key characteristics of SPICE are:

- The system is extremely multi-mission: it has been used on cruise, orbiting, landing and roving missions, and on almost every worldwide planetary mission starting with Magellan.
- The Toolkit is available for a large assortment of popular computing environments, including Fortran 77, C, IDL and MATLAB.
- The Toolkit is 100% backwards compatible: no delivered capability is ever removed or revised.
- The Toolkit is heavily documented, including provision of tutorials and programming lessons.
- The Toolkit is thoroughly tested before each new release.
- Source code is provided.
- All computations are double precision.
- There are no licensing, registration or distribution restrictions, and no costs for end users.
- Occasional training classes are offered, and modest user consultation if offered.
- For at least NASA and ESA planetary missions, archived SPICE data are well documented and freely available to all.

3. Looking Ahead

While SPICE has considerable maturity due to its long existence and extensive use, it is important that new capabilities be added to meet user's expectations and to accommodate new computing environments. This paper provides an overview of recent additions and work currently underway, such as the ability to search for specified geometric conditions, the addition of new, higher fidelity shape models, the addition of a Java Native Interface Toolkit, and provision of a web-based graphical user interface to a SPICE geometry engine. It also presents some thoughts about other possible enhancements, asking for audience suggestions. Some possibilities previously mentioned by SPICE users include addition of a thread-safe and object-oriented architecture, inclusion of accuracy information in calculations, addition of a star catalog, addition of a rings model, ability to perform footprint coverage computations, more comprehensive (accurate) instrument models, improvements to data file (kernel) management, close coordination with space geometry visualization tools, and advanced training classes. On-the-fly observation geometry computations might also be useful in science data searches spanning multi-national planetary data archives organized under the aegis of the International Planetary Data Alliance.

4. Summary and Conclusions

SPICE has slowly evolved to be the de facto standard in the worldwide planetary science community for dealing with most of the geometric and timing computations needed by scientists. (Many engineers who plan and operate robotic planetary missions also use SPICE.)

SPICE development and operations are best accomplished in close contact with end users–a diverse and widely scattered community. The EPSC is one of several forums useful for informing the science community about the existence of SPICE and about recent developments that might be useful. It equally affords a chance to garner user feedback regarding problems with existing capabilities and suggestions for new features.

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References

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